Developing a Relative Flash Flood Potential Index to Assist in the Flash Flood Warning Decision Making Process

Prepared by: Greg Smith (CBRFC)

NWS Workshop on Hydrologic Forecasting
Prague Campus
Czech University of Agriculture
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Concept:

Take a look at physical land surface characteristics that influence the hydrologic response to heavy rainfall.

An area containing physiographic features conducive to rapid and significant runoff from rainfall would be identified as having a greater flash flood potential threat relative to areas generating less runoff over longer periods of time.

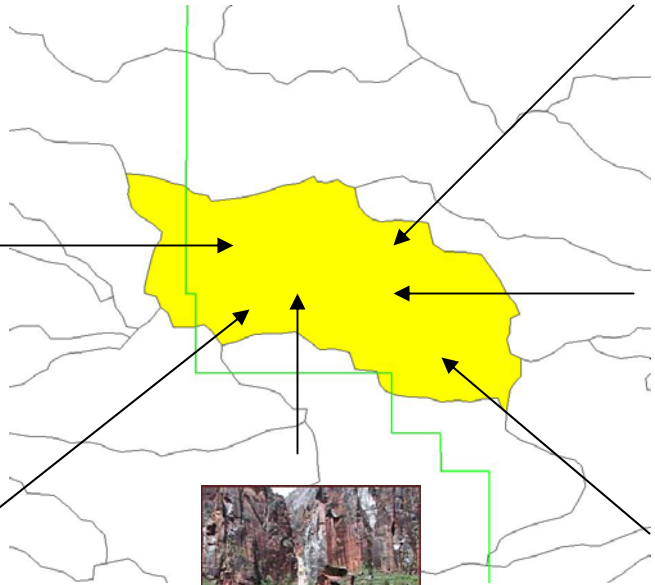
Determine a simplistic flash flood potential index, on a relative scale, from this analysis. Utilize this information to supplement FFMP and in attempts to generate finer resolution FFG.

Physiographic – Refers to the character and distribution of land forms.

Additional information perhaps helpful to know

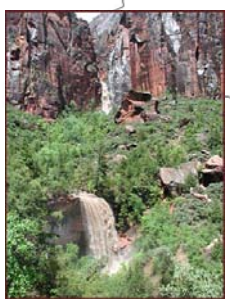
Land Use ?

Soil type ?



Vegetation type and density ?

Fire activity ?



Slopes?

Is the ground frozen?

Hydrologic Response To Heavy Rainfall

- Frozen Ground -

Flow Magnitude

Less ⟷ **More**

Slower ⟷ **Rapid**

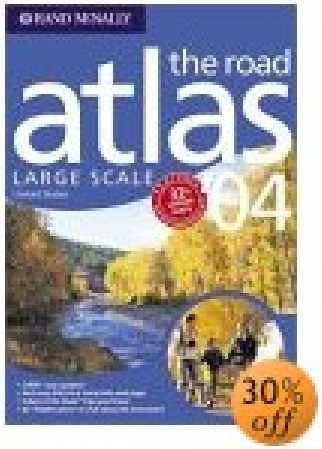
Flow Response Time

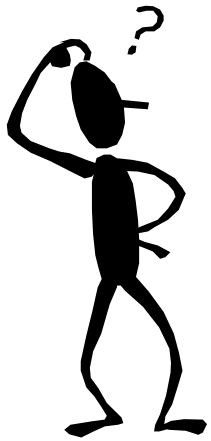
Flash Flood Potential

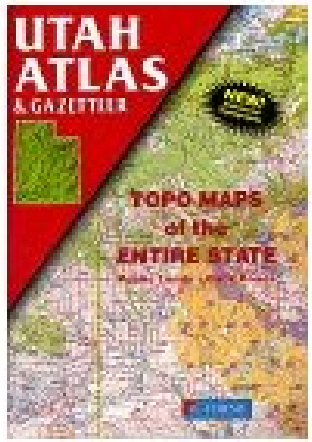
Lower ⟷ **Greater**

Accumulating Knowledge About A River Basin

Evaluating The Flash Flood Threat

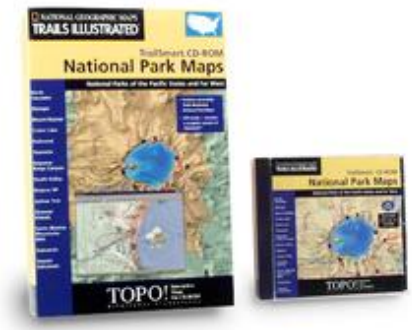






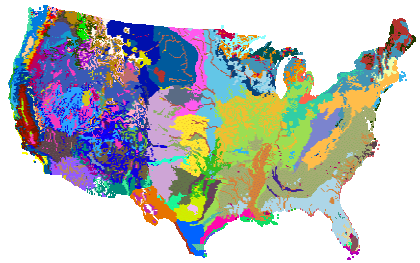
Difficult & Time Consuming During Active Weather

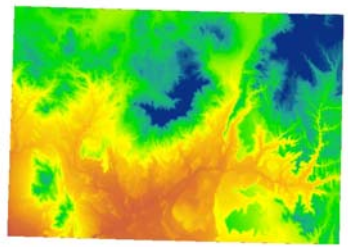
Hundreds or Thousands of Basins Under One Radar Umbrella !!

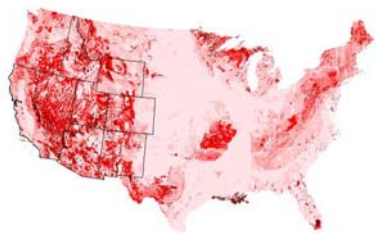


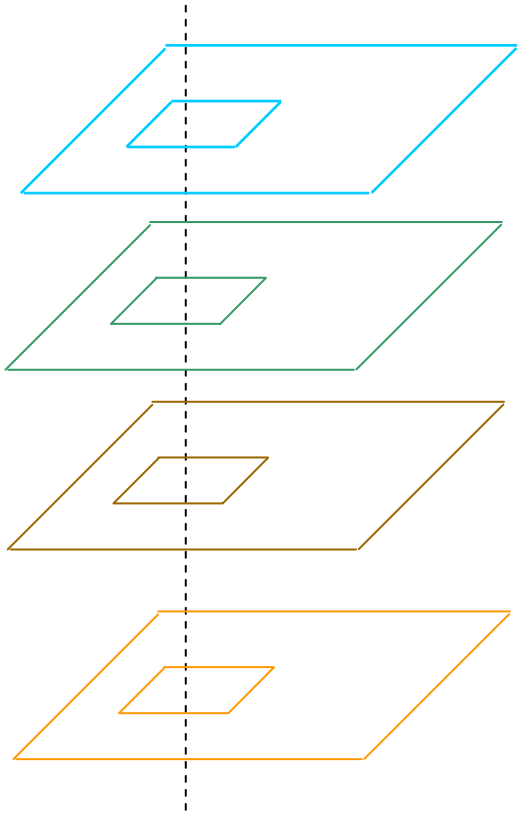
A Better Method: Utilizing GIS tools/methods to develop a single index that represents the a potential for flash flooding (on a relative scale)

obtain raster (gridded) datasets representing the features of interest









Slope

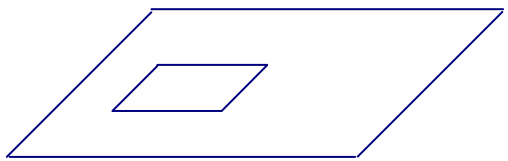
Vegetation

Soil Type

Land Use

Assign grid cell FFPI values of 1-10

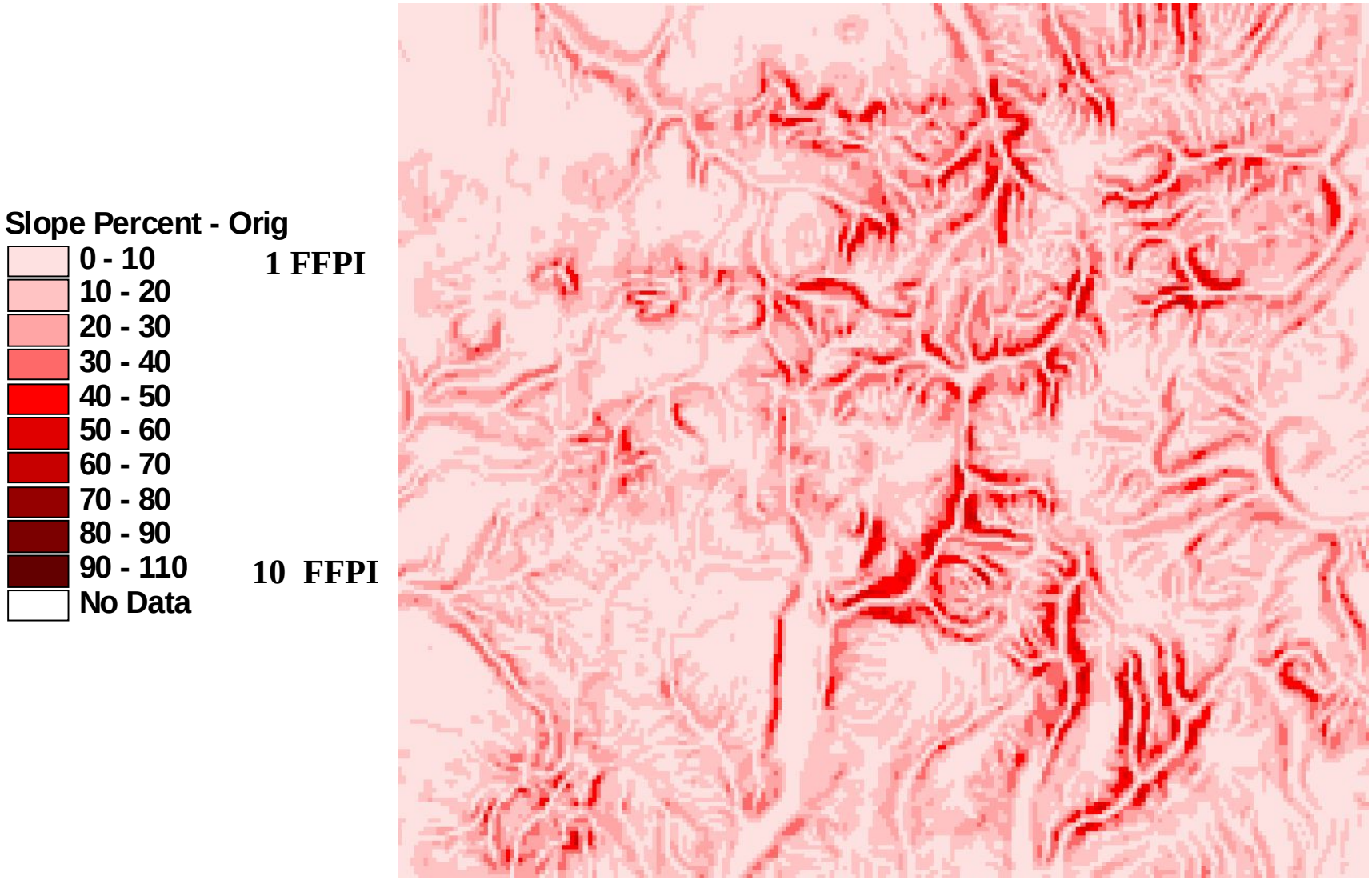
Based on attributes of the data layer

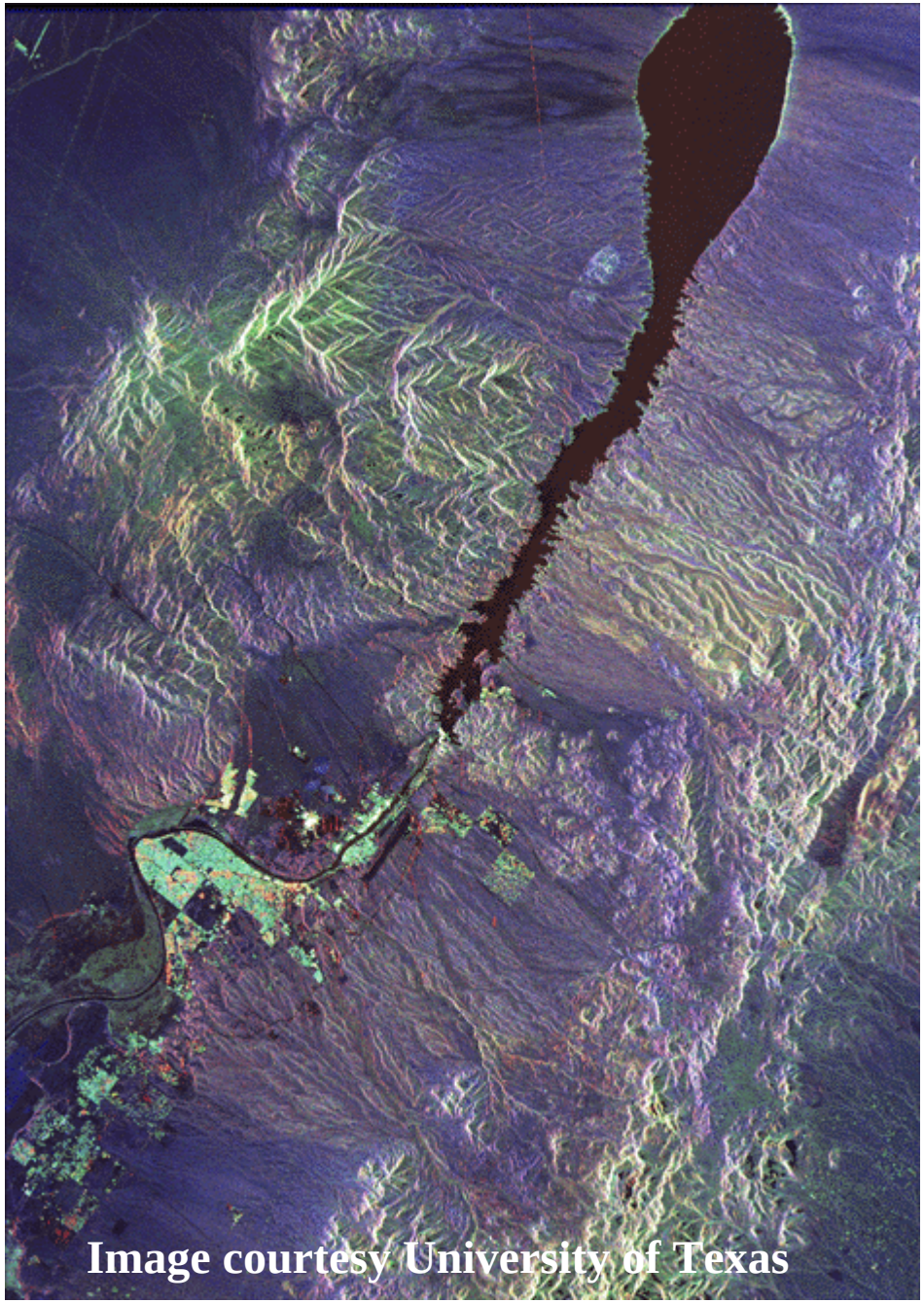


Output: Mean of all the data layers

Continuous Data Types

Equal Interval Classification



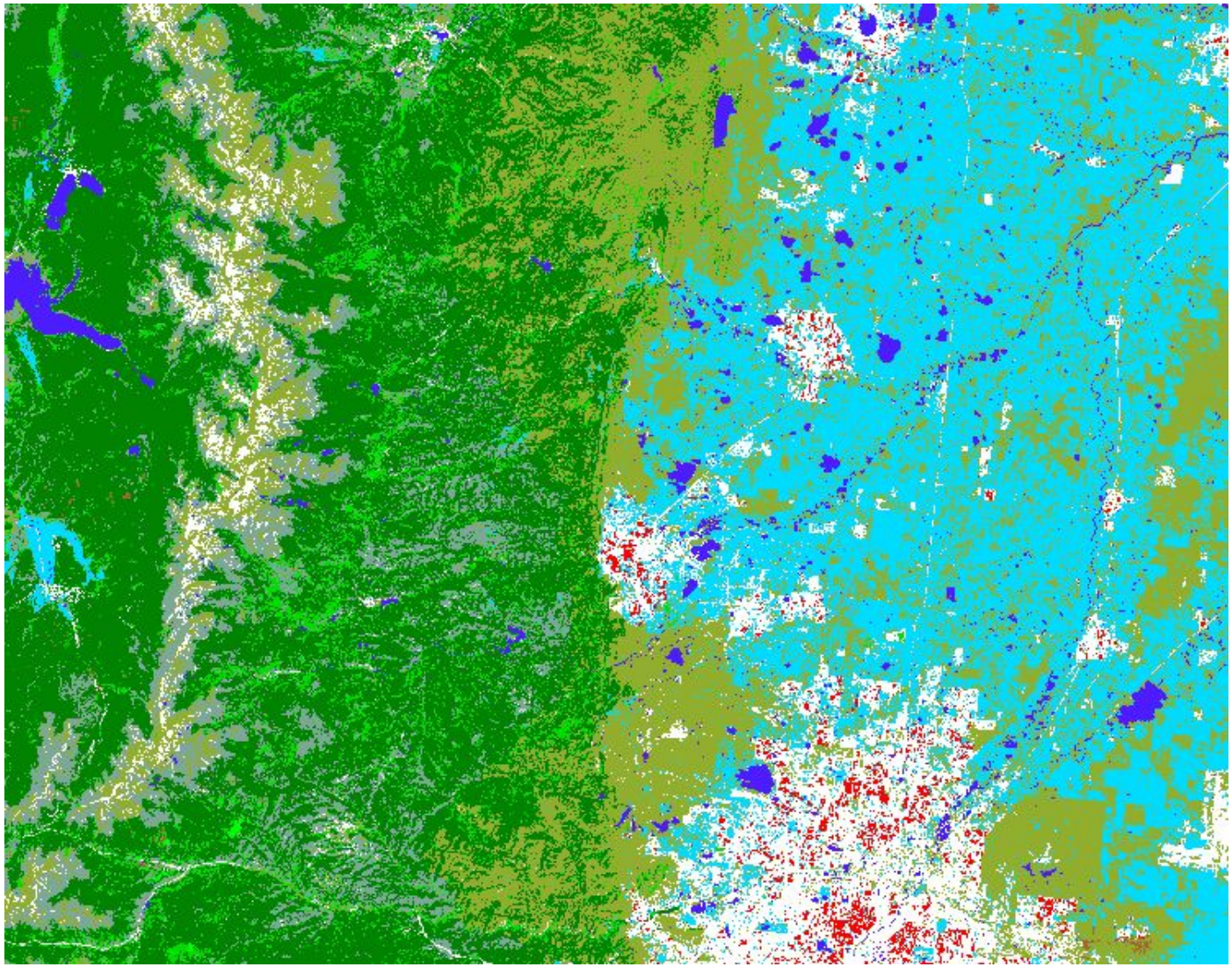


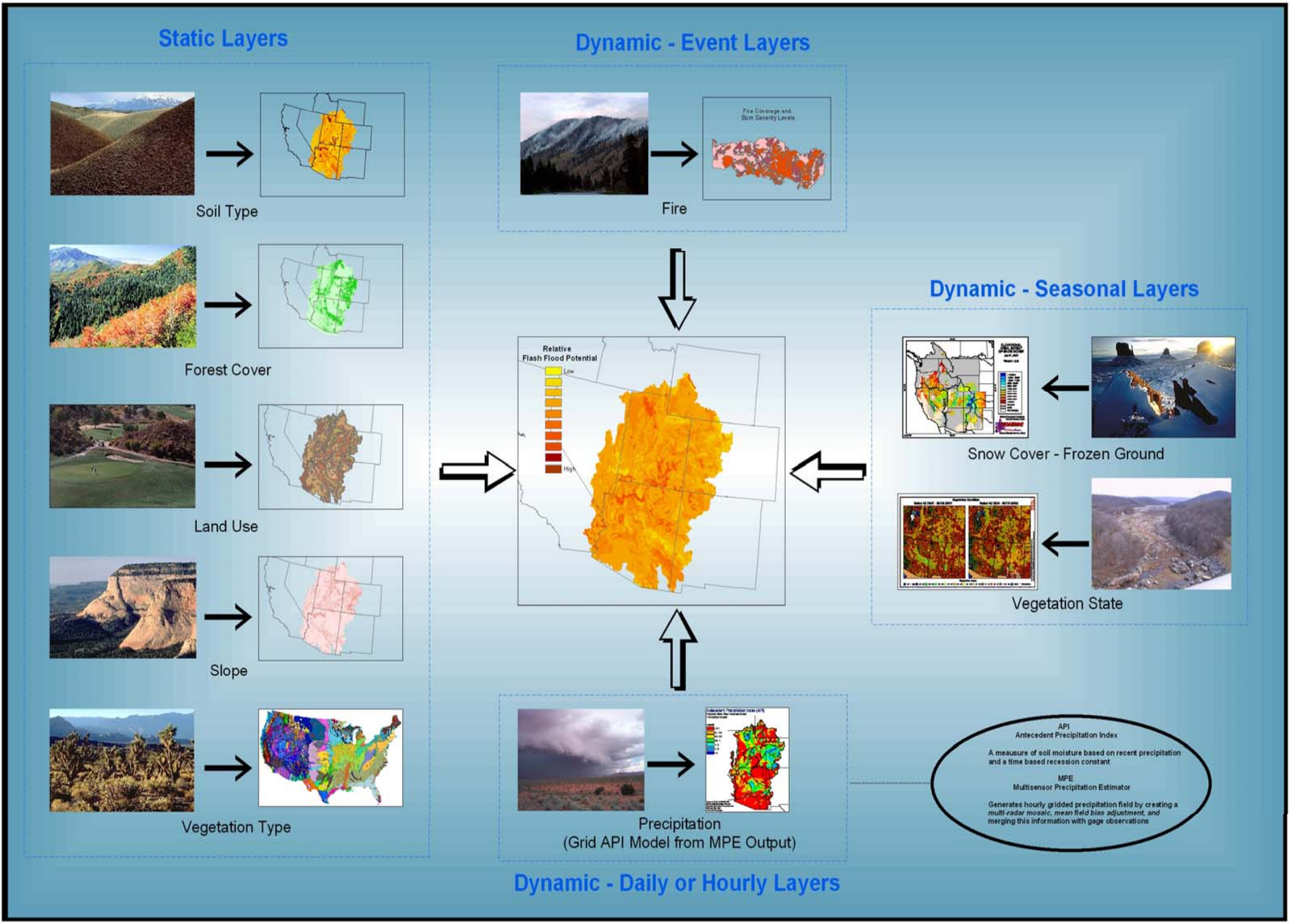
Urban Development along the Colorado River

The purpose of using this dataset is to highlight the urban areas.

Significant concern for WFO's central/eastern U.S.

Land-Use Dataset for Front Range of Colorado




Static Layers
Soil Type
Forest Cover
Land Use
Slope
Vegetation Type
Dynamic - Event Layers
Fire
Fire Coverage and
Burn Severity Levels
Relative
Flash Flood Potential
Low
High
Dynamic - Seasonal Layers
Snow Cover - Frozen Ground
Vegetation State
Precipitation
(Grid API Model from MPE Output)
Dynamic - Daily or Hourly Layers
API
Antecedent Precipitation Index
A measure of soil moisture based on recent precipitation and a time based recession constant
MPE
Multisensor Precipitation Estimator
Generates hourly gridded precipitation field by creating a multi-radar mosaic, mean-field bias adjustment, and merging this information with gage observations

Method (Initial)

$$RFFPI = (1.5 * slope + 1.0 * forest + 1.0 * soil + 1.0 * LU) / N$$

RFFPI = Relative Flash Flood Potential Index

Slope = Percent Slope

Forest = Forest Cover

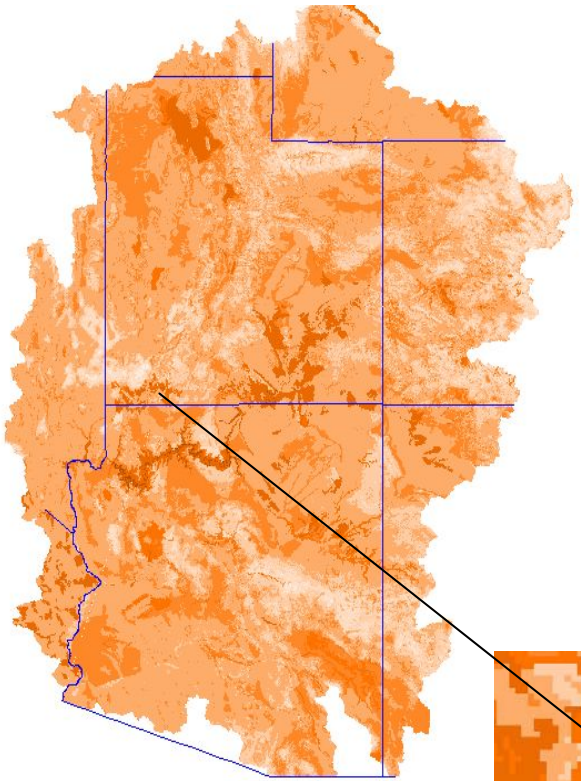
Soil = Soil Type (fractional soil grid)

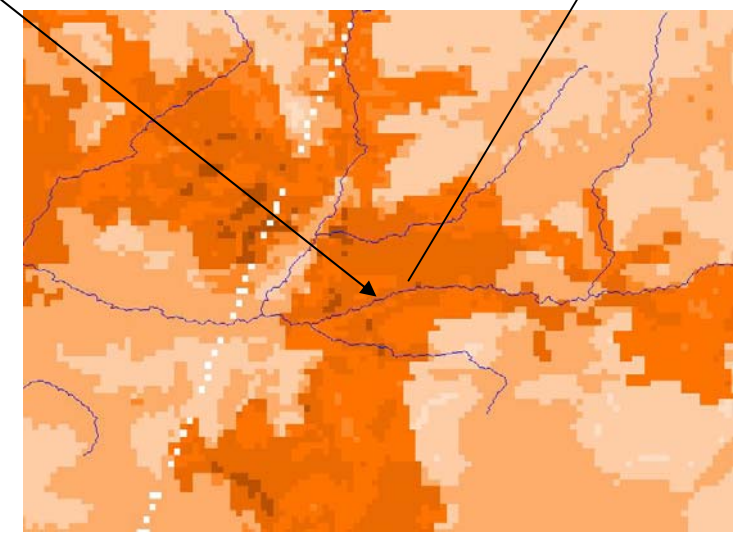
Land Use = Land Use Type

N = Number of Layers

More layers will be added

Gridded –Relative– Flash Flood Potential





Summarize Grids to FFMP Basin Layer

STATSGO Dominant Soil Texture

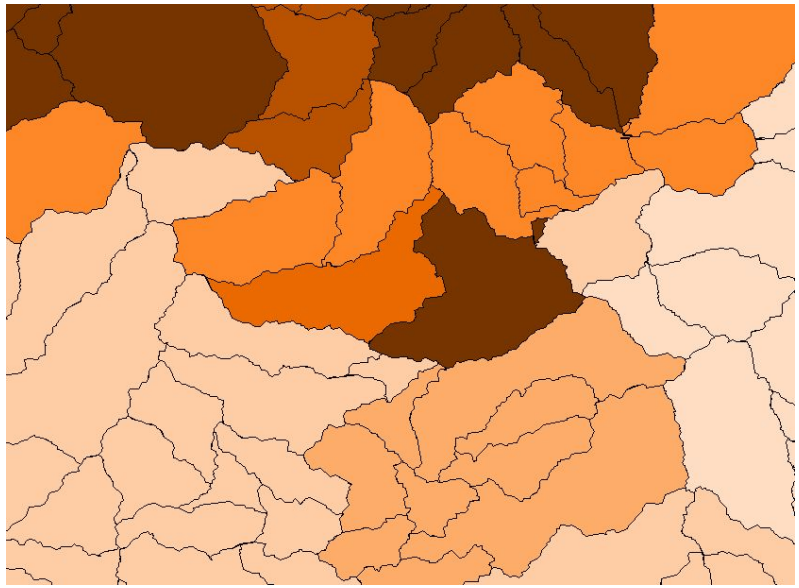
MLRC Land Use / Land Cover

NOAA AVHRR Forest Density Grid

USGS DEM (derived % slope Grid – Terrain)

Fire Burn Areas / Severity coverage

FFMP Basins



Relative Flash Flood Potential

Low

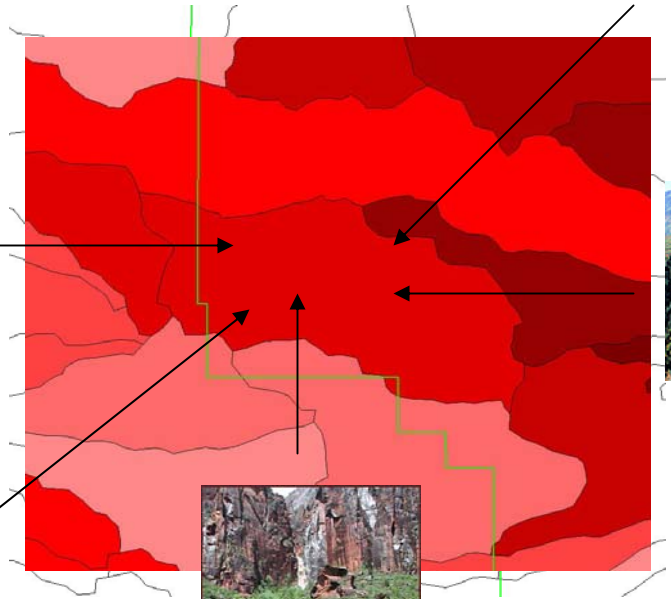
High

An indication of rapid hydrologic response

Additional information perhaps helpful to know

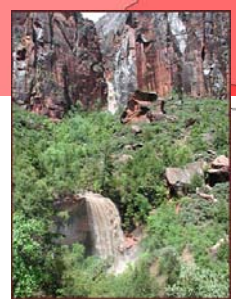
Land Use ?

Soil type ?

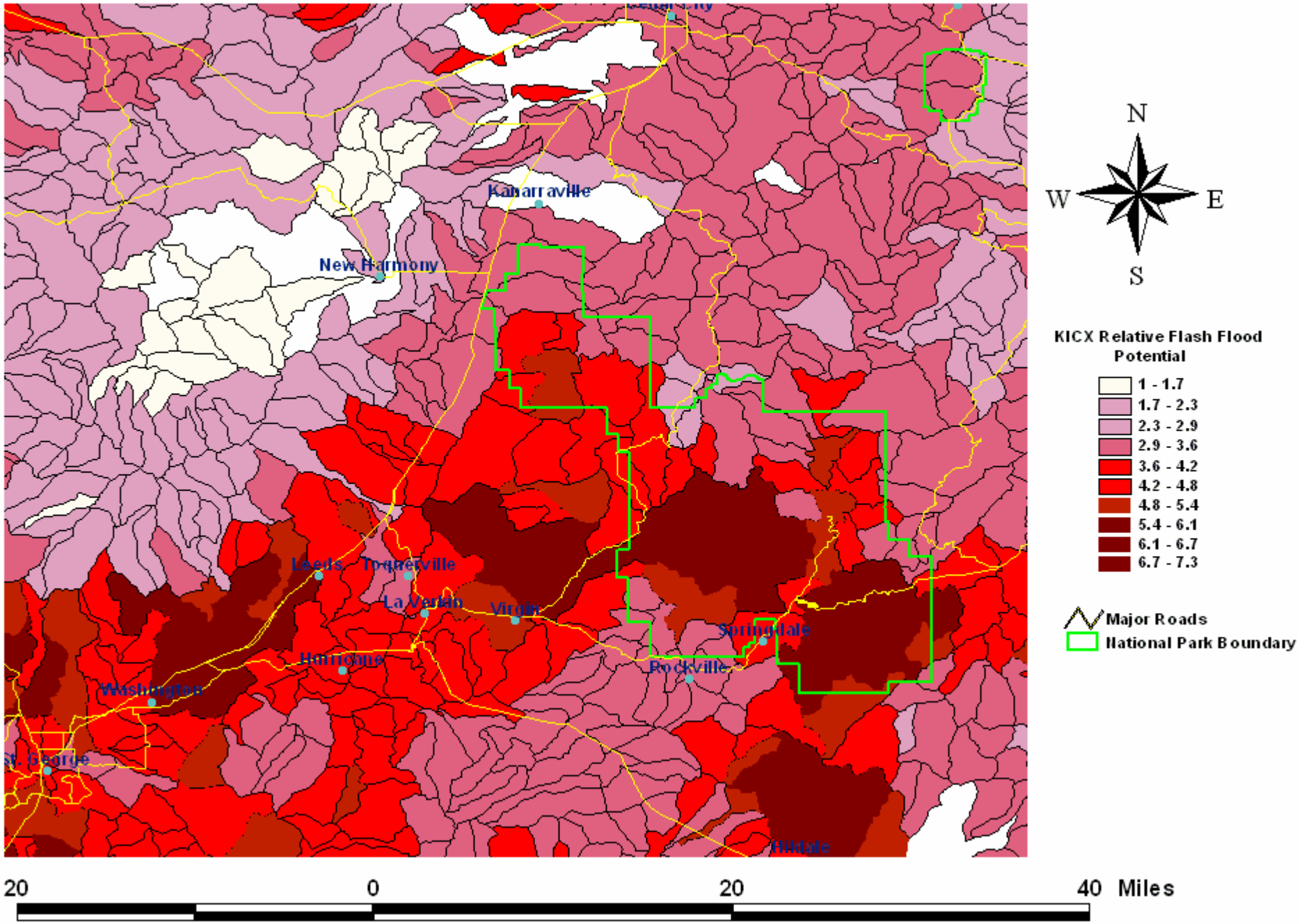


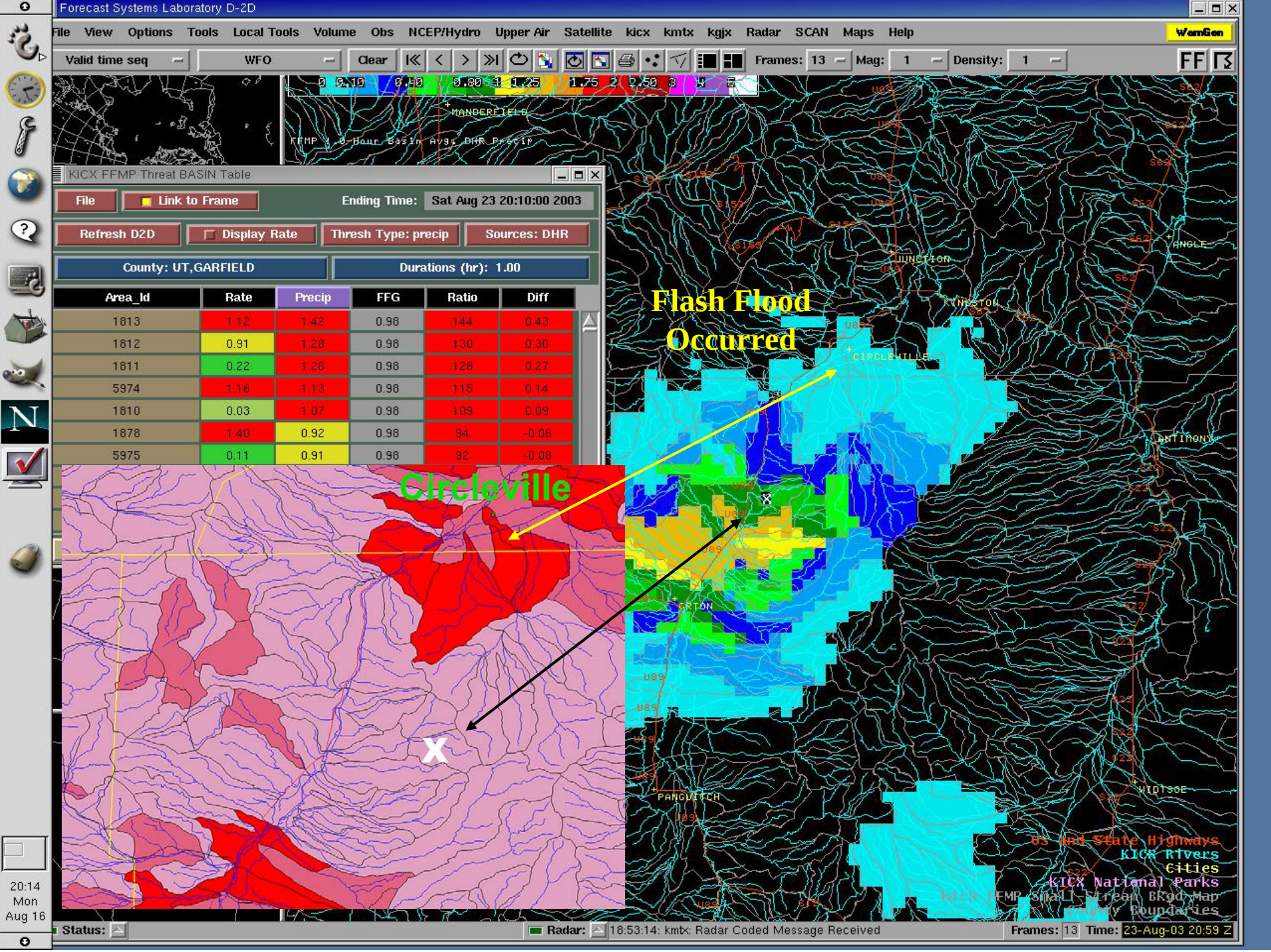
Vegetation type and density ?

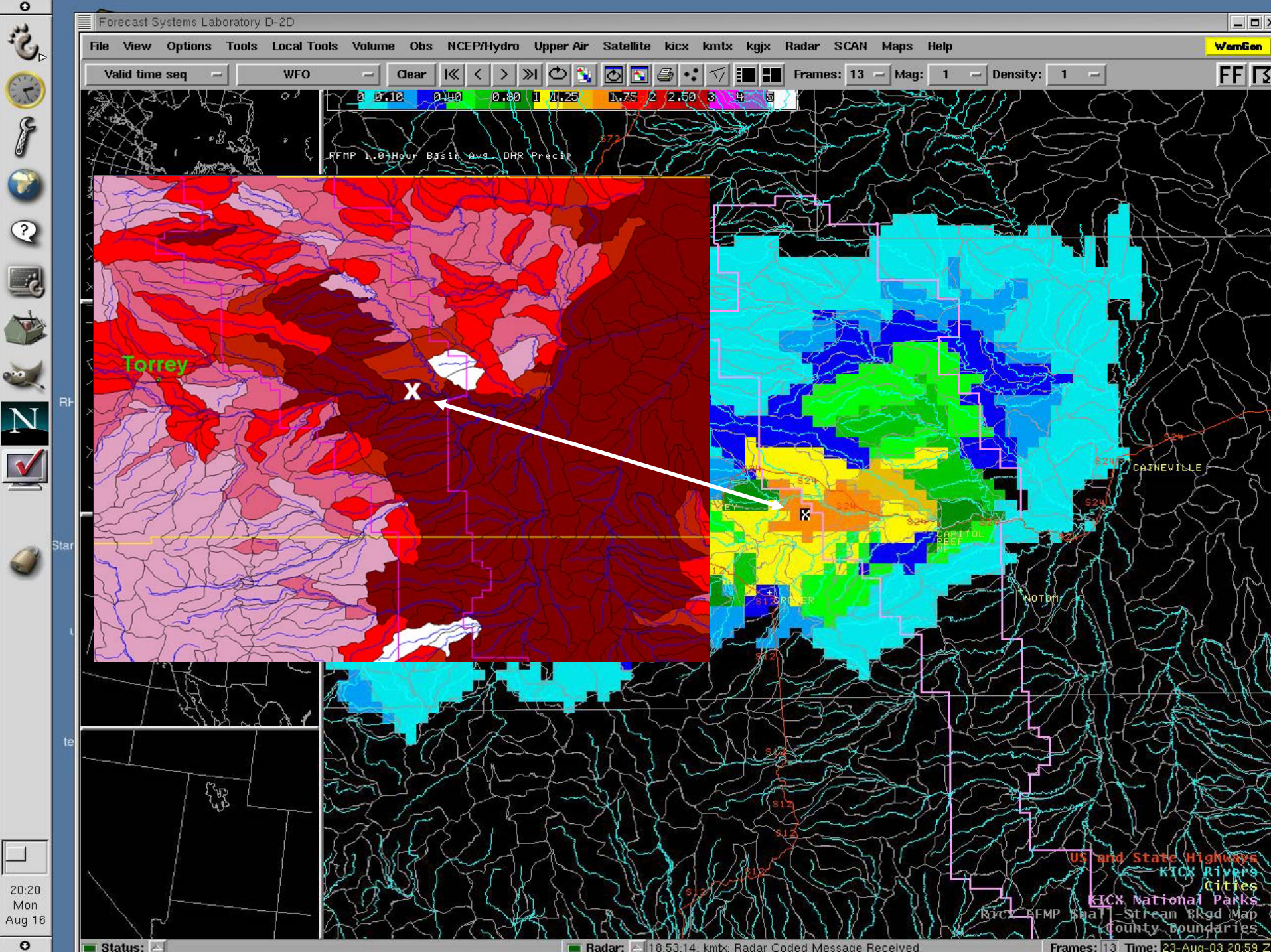
Fire activity ?



Slopes?


Kanarraville
New Harmony
Leeds
Toquerville
La Verkin
Virgin
Hurricane
Washington
St. George
Springdale
Rockville
Hildale
N
W
E
S
KICX Relative Flash Flood Potential
1 - 1.7
1.7 - 2.3
2.3 - 2.9
2.9 - 3.6
3.6 - 4.2
4.2 - 4.8
4.8 - 5.4
5.4 - 6.1
6.1 - 6.7
6.7 - 7.3
Major Roads
National Park Boundary
20
0
20
40 Miles


Forecast Systems Laboratory D-2D
File View Options Tools Local Tools Volume Obs NCEP/Hydro Upper Air Satellite kicx kmtx kgjx Radar SCAN Maps Help
WarnGen
Valid time seq
WFO
Clear
Frames: 13
Mag: 1
Density: 1
KICX FFMP Threat BASIN Table
File
Link to Frame
Ending Time: Sat Aug 23 20:10:00 2003
Refresh D2D
Display Rate
Thresh Type: precip
Sources: DHR
County: UT,GARFIELD
Durations (hr): 1.00
Area_Id Rate Precip FFG Ratio Diff
1813 1.12 1.42 0.98 144 0.43
1812 0.91 1.28 0.98 130 0.30
1811 0.22 1.26 0.98 128 0.27
5974 1.16 1.13 0.98 115 0.14
1810 0.03 1.07 0.98 109 0.09
1878 1.40 0.92 0.98 94 -0.06
5975 0.11 0.91 0.98 92 -0.08
Flash Flood Occurred
Circleville
X
MANDERFIELD
JUNCTION
KINGSTON
CIRCLEVILLE
ANGLE
ANTIMONY
ORTON
PANGUITCH
WIDTSOE
US and State Highways
KICX Rivers
Cities
KICX National Parks
KICX FFMP Small Stream Bkgd Map
County Boundaries
20:14
Mon
Aug 16
Status:
Radar:
18:53:14: kmtx: Radar Coded Message Received
Frames: 13
Time: 23-Aug-03 20:59 Z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WarnGen
Valid time seq
WFO
Clear
Frames: 13
Mag: 1
Density: 1
0 0.10 0.40 0.80 1 1.25 1.75 2 2.50 3 4 5
FFMP 1.0-Hour Basin Avg DHR Precip
Torrey
X
CAINEVILLE
CAPITOL REEF NP
US and State Highways
KICX Rivers
Cities
KICX National Parks
County Boundaries
Status:
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20:20
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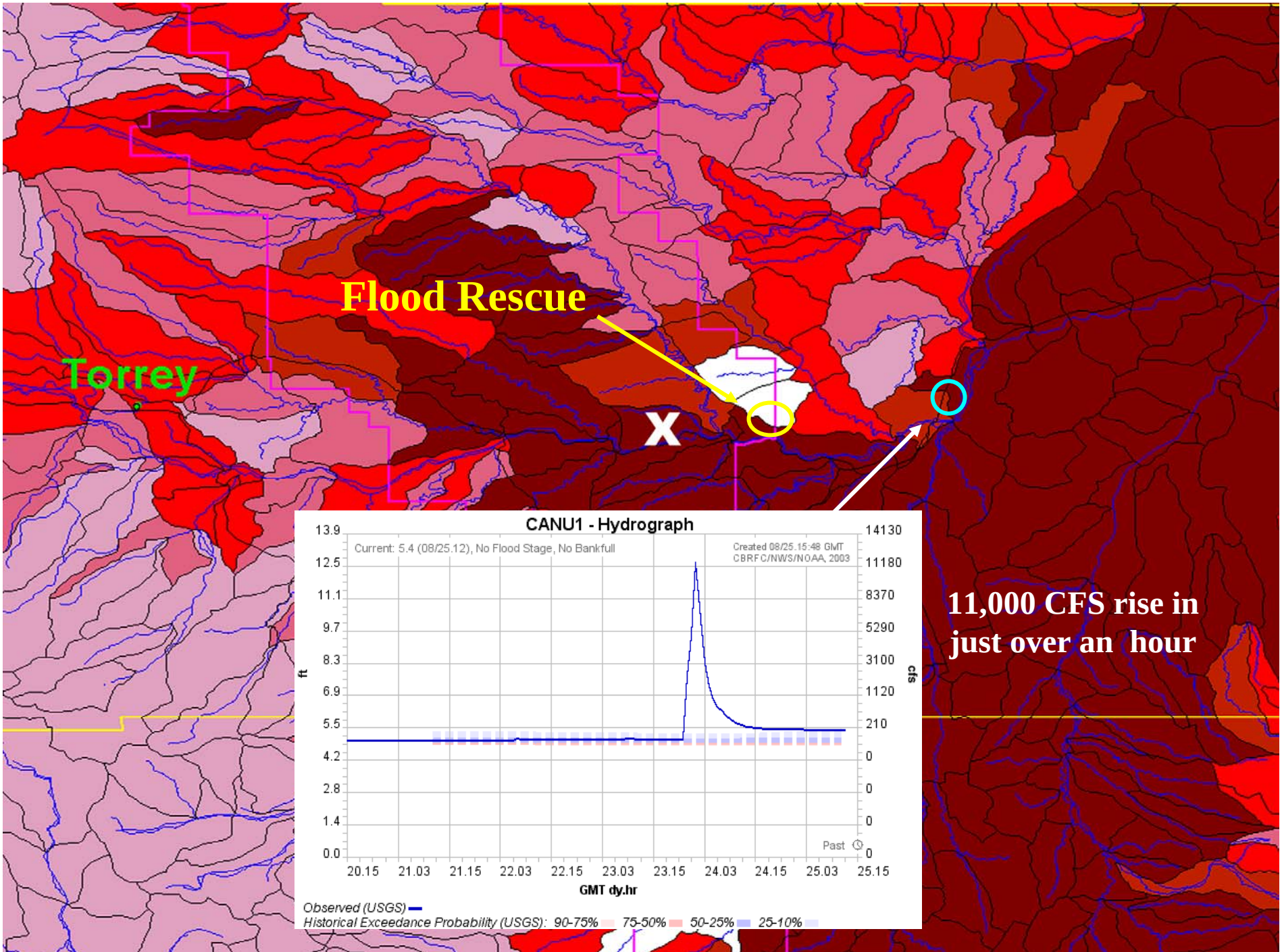

Flood Rescue
Torrey
X
CANU1 - Hydrograph
Current: 5.4 (08/25.12), No Flood Stage, No Bankfull
Created 08/25.15:48 GMT
CBRFC/NWS/NOAA, 2003
ft
13.9
12.5
11.1
9.7
8.3
6.9
5.5
4.2
2.8
1.4
0.0
cfs
14130
11180
8370
5290
3100
1120
210
0
0
0
0
Past
20.15
21.03
21.15
22.03
22.15
23.03
23.15
24.03
24.15
25.03
25.15
GMT dy.hr
Observed (USGS)
Historical Exceedance Probability (USGS): 90-75% 75-50% 50-25% 25-10%
11,000 CFS rise in just over an hour

So How Might This Be Utilized ?

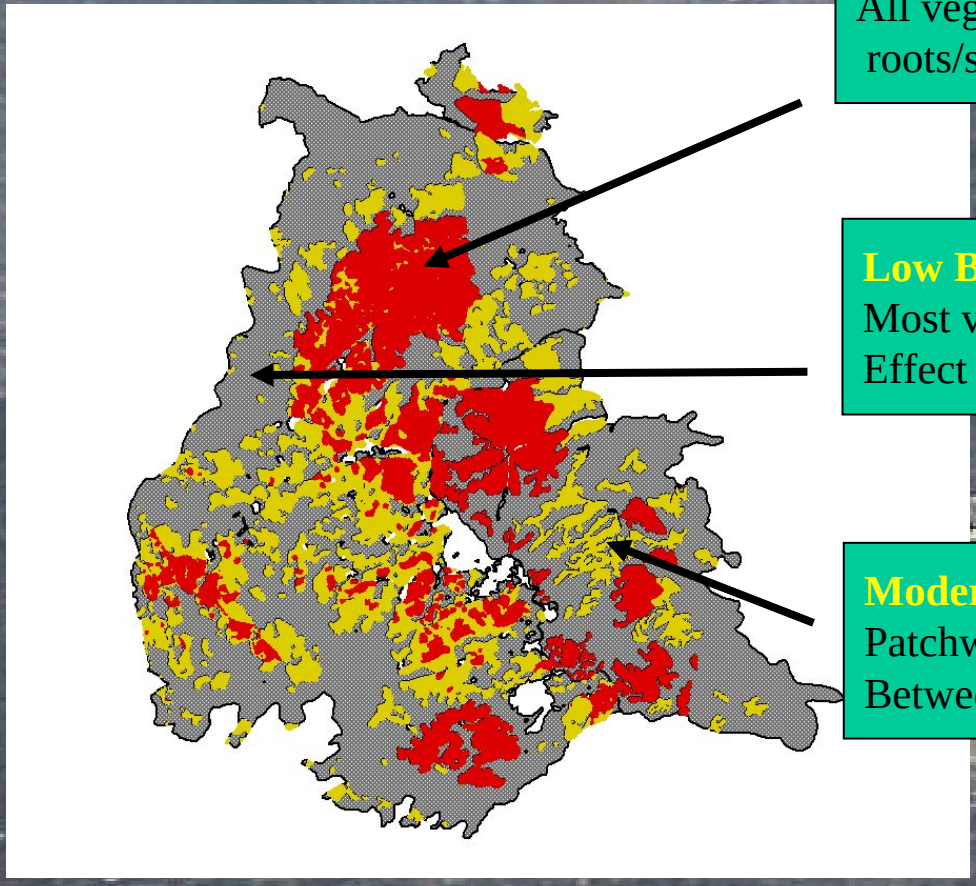
Supplement FFMP and provide additional information in the flash flood warning decision making process

As a starting point for an alternate method creating FFG

- Takes into account physiographic features influence flash flooding
- Incorporates observed FF event information
- CBRFC: Spatially vary current zone FFG from the Legacy System

Accounting For Effect of Wildfires

John McColgan – BLM Firefighter



High Burn Severity:
All vegetation blackened, deep soil heating killing roots/seeds, “baking” of the soil surface.

Low Burn Severity:
Most vegetation untouched by fire. No significant Effect on soil properties or water repellency.

Moderate Burn Severity:
Patchwork of green and burnt areas. Intermediate Between “high” and “low” severity levels.

The Challenge: How to apply fire burn severity information ?

Forest Density Layer :

- **High Burn Area – Completely removed forest density**

  Maximized hydrologic response for this layer

- **Moderate Burn Areas - Reduced forest density by 50%**

  Moderate increase to hydrologic response for this layer

- **Low or non burn areas – No change to existing forest density**

  No change to hydrologic response for this layer.

The Challenge: How to apply fire burn severity information ?

Soil Type Layer :

- **High Burn Area – Assume hydrophobic soil**

  Maximized hydrologic response for this layer

- **Moderate Burn Areas – Mix of baked / non-baked soil exists**

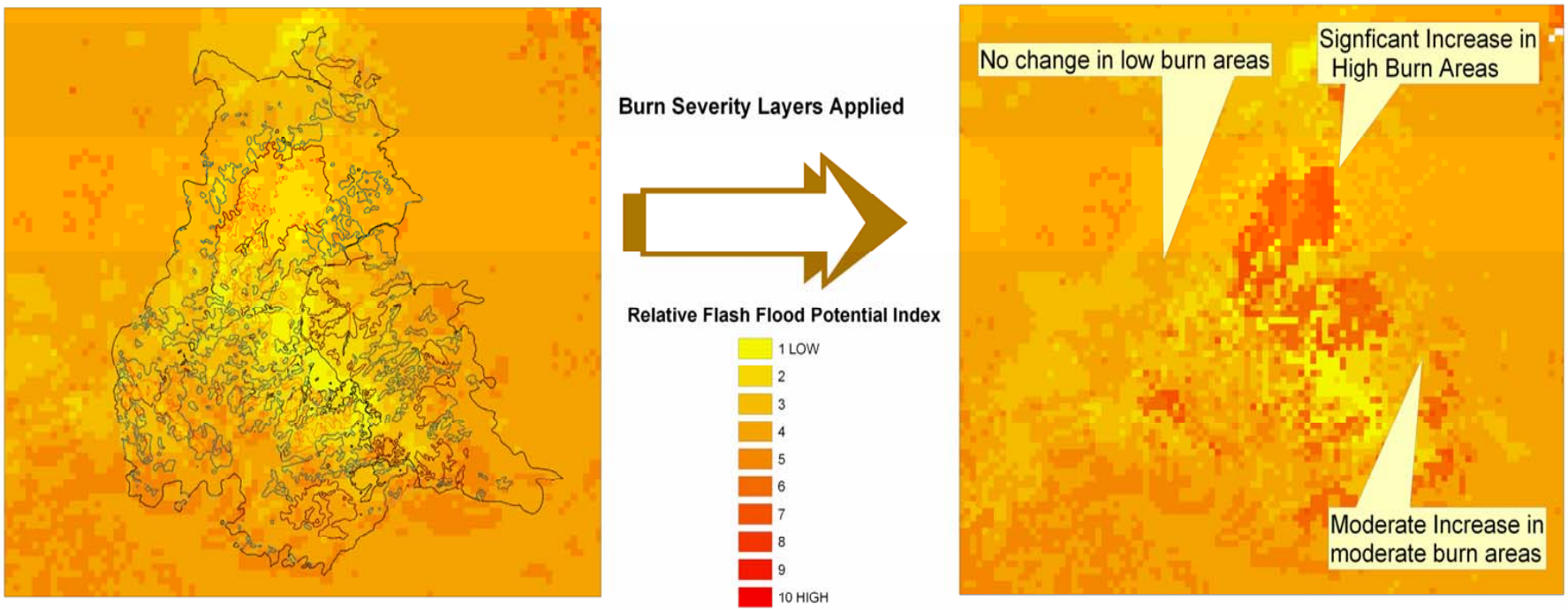
  Moderate increase to hydrologic response for this layer

- **Low or non burn areas – No change to existing soil properties**

  No change to hydrologic response for this layer.

Affect of Fire on Hydrologic Response and Gridded Relative Flash Flood Potential

* Preliminary Results *

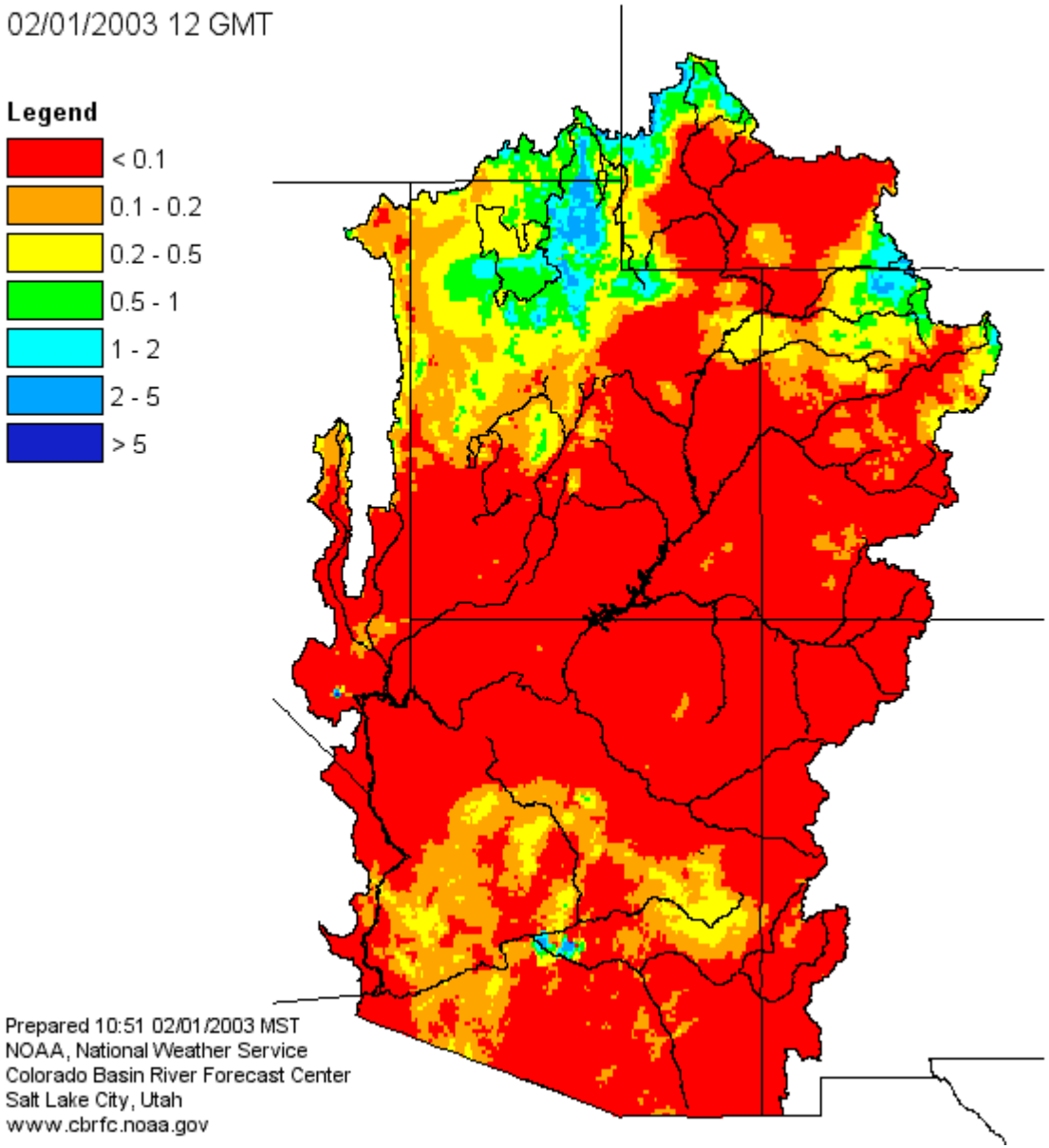


Prepared by: Greg Smith - Colorado Basin River Forecast Center - NWS/NOAA

Antecedent Precipitation Index (API)

Colorado Basin River Forecast Center

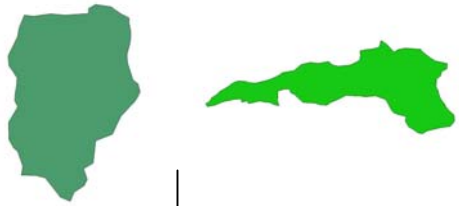
02/01/2003 12 GMT



Prepared 10:51 02/01/2003 MST
NOAA, National Weather Service
Colorado Basin River Forecast Center
Salt Lake City, Utah
www.cbrfc.noaa.gov

This is inside a national park; is that a risk factor to consider?

Geometry of basin



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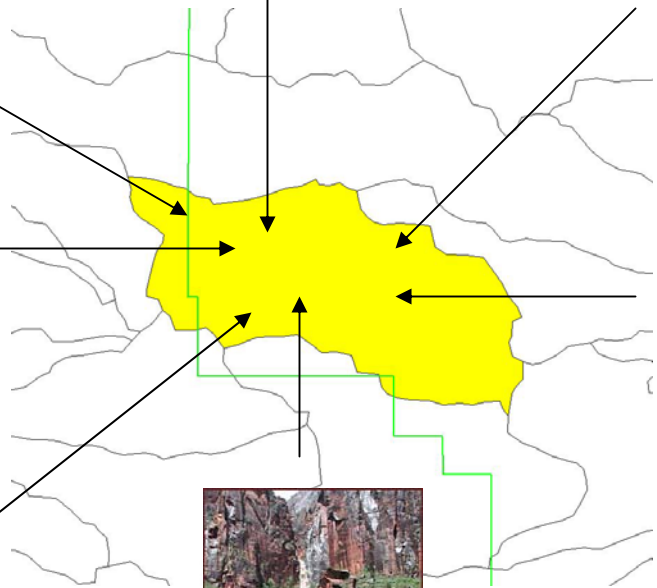

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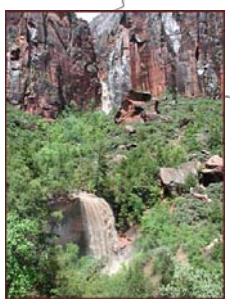


Slopes?

Is the ground frozen?

Limitations & Challenges

GIS Datasets

Resolution issues, derived data, source information, accuracy issues, applicability, error propagation, etc.

Wildfire Data

No clearinghouse for obtaining such information – Incorporate wildfire recovery.

Observed FF Event Information

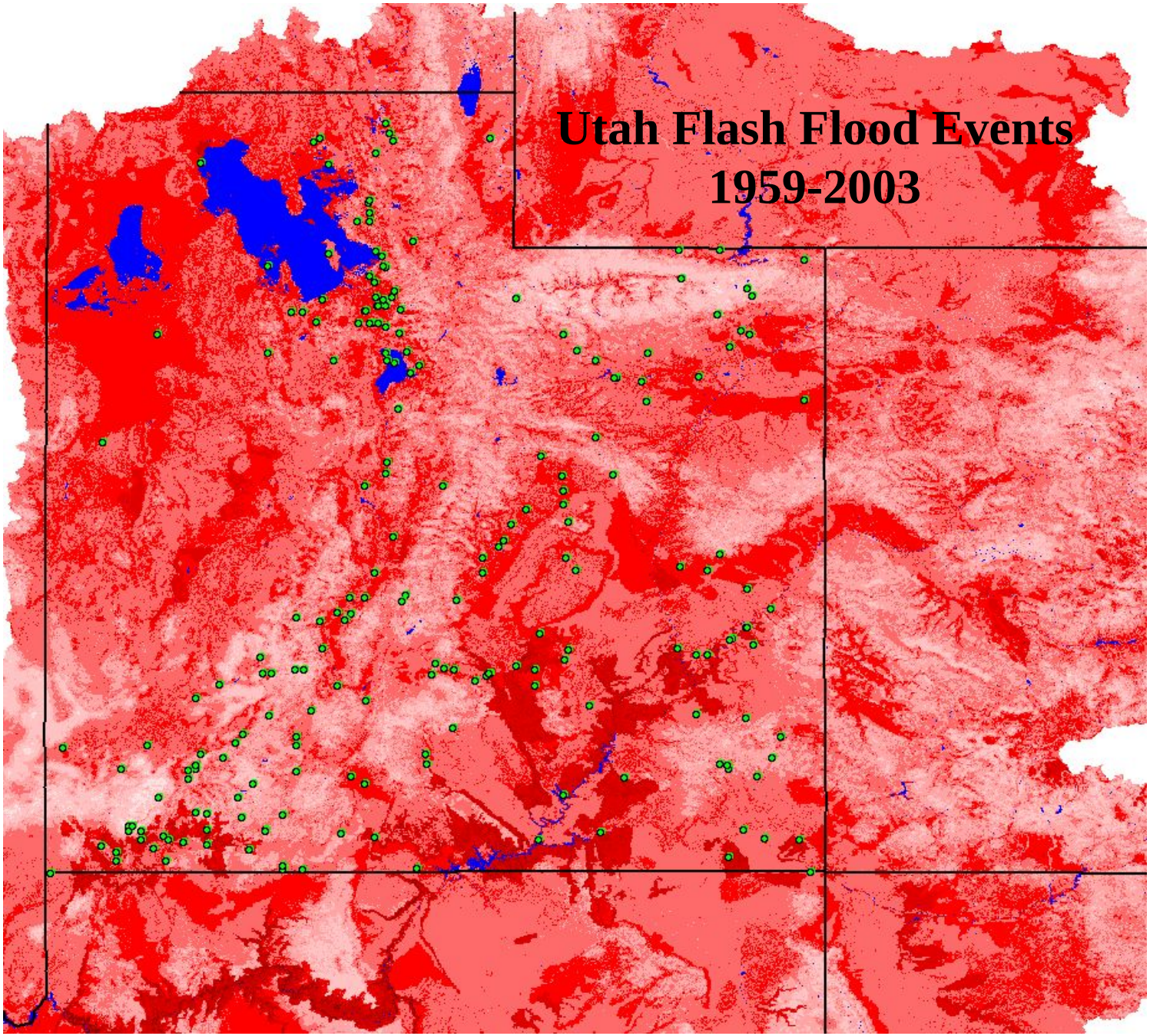
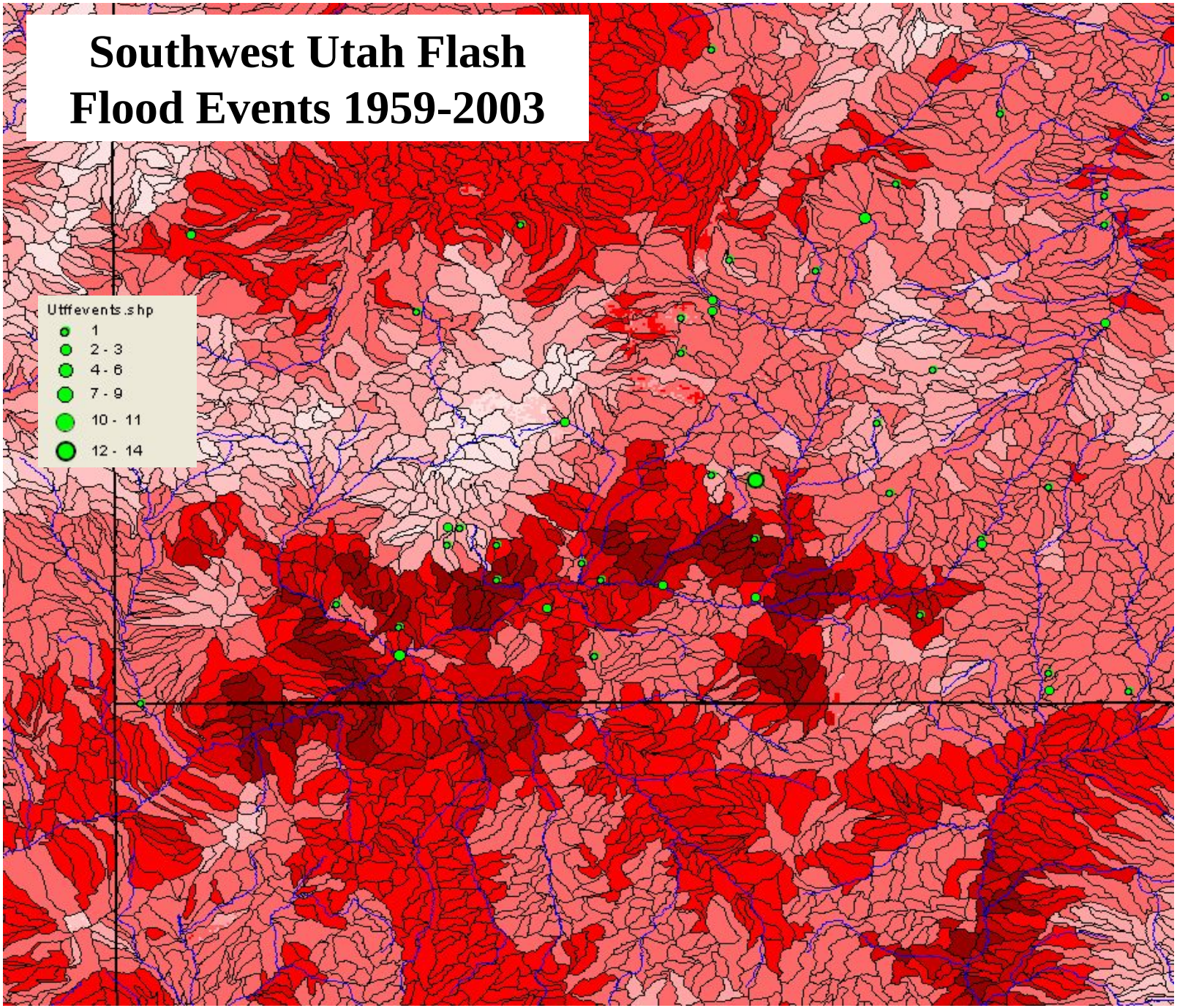
Limited, scattered, time consuming to acquire.

Current Assumptions – Layer Weighting Schemes

Observed event data needed for more robust application

Finding the Right Platform

How best to display – utilize such information.


Utah Flash Flood Events
1959-2003

Southwest Utah Flash Flood Events 1959-2003